State of Minnesota Guidelines for Managing Indoor Air Quality

Introduction to Indoor Air Quality

What is indoor air quality?

Indoor air quality (IAQ) is a common term used to describe the quality of air within a building environment. The increase in knowledge regarding indoor air quality in recent years has established the need to actively manage many physical factors that can affect our perception of a building's air quality.

The goal of managing IAQ is to create an environment that is acceptable to all building occupants. It should be noted however that this is no small task and may not be attainable. There may be as many different perceptions of the air quality as there are building occupants. This is evident in the standards developed by the American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). ASHRAE Standard 62-1989 (ventilation for acceptable indoor air quality) defines acceptable indoor air quality as "air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction." Does this definition mean we can ignore the remaining 20 percent of the building occupants? Our goal should be a substantially higher percentage of satisfied occupants.

Additionally, individual building occupants may be more susceptible to indoor contaminants. Even if identification of the causative agent is possible, it may not be reasonably feasible to eliminate the indoor exposure from the individual.

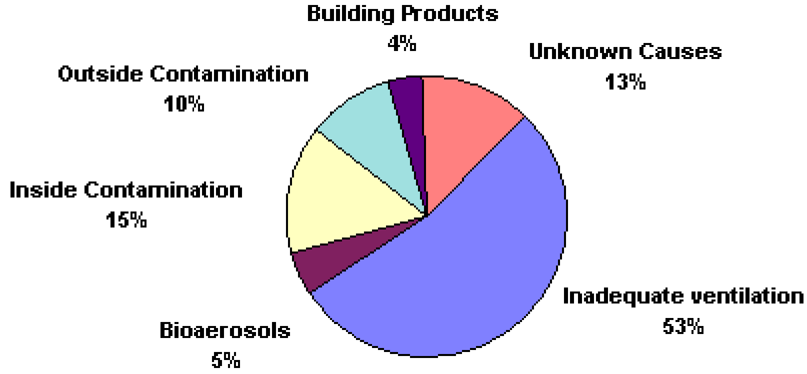
This manual has been created to help you manage all aspects of indoor air quality at your facility. It is designed to be used as a procedural document as well as a reference tool offering guidance in handling indoor air quality issues.

Included in the appendices is the air quality guide developed by the Air Quality Task Force from which this manual came into existence. Also included is the Environmental Protection Agency document *Building Air Quality*. This document is an excellent resource for further study of IAQ issues.

What causes IAQ problems?

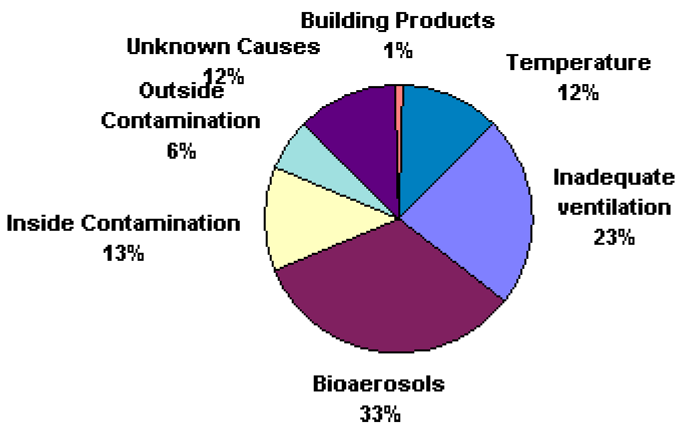
Many factors can affect how we perceive the air quality in a particular building. The National Institute for Occupational Safety and Health (NIOSH) has completed several IAQ investigations. Figure 1. identifies NIOSH's conclusions regarding the typical cause of the IAQ concerns.

Figure 1. NIOSH Air Quality Investigations



In conducting indoor air quality surveys, DOER has found six major sources of concerns. Figure 2. details these findings.

Figure 2. DOER Investigation Results



Many of the causes of IAQ concerns can be attributed to interesting global occurrences such as the energy crisis of the early 1970's. The rapid increase in energy costs required architects and engineers to utilize modified building construction techniques and mechanical systems designed to minimize the cost associated with conditioning indoor environments. One solution was to require any introduction of outside air into the building only through the heating, ventilating and air conditioning (HVAC) system. One way this was accomplished was by installing windows that could not be opened. This has lead to so called "tight building syndrome."

The extensive use of chemicals in today's society also contributes to IAQ concerns. Volatile organic compounds (VOCs) are emitted during normal use of many office products. Examples of office products that can emit VOCs include markers and correction fluid. Normal ventilation, the introduction of outside air, is usually sufficient to dilute these chemicals to concentrations that are not noticeable. However, if ventilation is inadequate these chemicals may cause irritation and other symptoms.

Other sources of IAQ concerns have been linked to microorganisms such as molds, fungi, and bacteria. The inability of building air handling systems to adequately control humidity and the common practice of insulating internal surfaces of duct work can lead to ideal growing conditions for a wide variety of microbial agents. Additionally, HVAC designs have not typically included access panels in high humidity locations such as cooling coils and humidification systems to facilitate appropriate cleaning schedules. Many microorganisms can cause allergic response in building occupants while others can cause serious illness.

A more thorough discussion of factors affecting indoor air quality can be found in Appendix B, pages 5-12. IAQ concerns can also be related to other factors in the work environment that are not actually related to indoor air quality. These factors are discussed in Appendix B, pages 77-79.

What can you do?

The goal of this manual is to provide an easy means for employees to reduce the number of IAQ concerns in buildings owned or leased by the State. Where IAQ concerns do exist, the manual will help the user identify common potential causes and a protocol for dealing effectively with IAQ concerns.

This information should be copied and shared with all individuals at your facility who are involved with indoor air quality management. **To facilitate the distribution of updated material, please provide the names and mailing addresses of everyone who receives a copy of this document to the Department of Employee Relations, Safety and Industrial Hygiene Unit at the phone numbers listed in the Acknowledgments**. The following form can be used to fax the pertinent document holder information. Document holders will then be included on a mailing list allowing them to receive future information and additions to this manual.

Document holder data

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Indoor Air Quality Management System

Occupant relationships

The relationships among building owners, management, staff and occupants are important factors in decisions that affect indoor air quality. The objectives of the major players in these relationships may be very different. Occupants want the building to be pleasant, safe and attractive and they want to get the maximum use out of the space they rent, for the least cost. Private building owners and management want to maintain a reputation for providing quality property at a reasonable cost, but also must derive a profit. Building maintenance staff are often caught in the middle, trying to control operating and maintenance costs, while still keeping the occupants satisfied.

Building occupants, staff and management share the goal of providing a healthy indoor environment. Recognition of this common goal may help avoid conflict when discussing many of these issues.

Any building management system will only be successful if it is organized to fit the specific building and its unique occupant relationships. This manual's main purpose is to provide guidelines to building owners and facility managers regarding the operation of buildings with acceptable indoor air quality for building tenants. All buildings are different and these procedures will require customization to suit your building.

The IAQ manager

Indoor air quality management will be facilitated if one individual is given overall responsibility for IAQ. This individual should have a good understanding of the building's structure and function and should be able to communicate with tenants, facility personnel and building owners. The IAQ manager should have the following responsibilities:

- establish an effective and efficient communication system with occupants and management,
- review and coordinate staff activities that affect indoor air quality,
- review remodeling or renovation projects for potential IAQ impact,
- review contracted services (cleaning services, pest control) for potential IAQ impact,
- periodically inspect the building for indicators of IAQ problems,
- respond to IAQ concerns by occupants,
- communicate status of investigation of any IAQ concerns.

These responsibilities will be discussed in greater detail in this section.

Who should be the IAQ manager?

The responsibilities of the IAQ Manager are very diverse and demanding. Ideally the IAQ Managers sole responsibility would be handling IAQ issues. However, in today's world of shrinking budgets, the role of the IAQ Manager will more than likely be taken on by an individual whose primary responsibilities will be in some other field. The IAQ Manager must be an effective communicator who has the ability to work with building occupants and management on an equal basis. The IAQ Manager must also be able to remain impartial while responding to IAQ concerns.

It may not be feasible to assign all of the responsibilities to a single individual. It may be necessary to split the IAQ Manager responsibilities between two or more individuals. When responsibilities are shared, it is critical to clearly define the separation of responsibilities to those affected, and to the building occupants.

Possible candidates for the IAQ Manager may be:

- Site Safety Contact
- Facility Building Engineer
- Staff Nurse
- Health and Safety Committee Member

The above individuals are only suggestions for the IAQ Manager and may not be available or appropriate for the position at your facility.

Establishing an effective communication system

An effective communication system for addressing IAQ concerns must be established by the IAQ Manager and supported by your buildings management. The purpose of the communication system is to serve as an information transport system between the building occupants, the IAQ Manager, and the building management. An effective communication system will allow for efficient handling of IAQ concerns. Refer to Chapter 3 of Appendix B for a more thorough discussion of communication systems.

Individuals should be identified in each work unit or building section as the Area IAQ Contact. These individuals would be responsible for helping the IAQ Manager collect and disseminate information to building occupants. Another common form of communication when addressing IAQ concerns is the formation of an IAQ committee or task force.

In order to be effective your communication system must define the responsibilities of all individuals involved with IAQ issues including the building occupants and building management. Occupants that have an IAQ concern should follow the notification protocol established by the IAQ Manager.

The communication system should also be used to update building occupants as to the status of IAQ concerns and their investigation. The content of communications should include the following information:

- types of IAQ complaints management has received
- management’s policy to provide a healthy and safe environment and how to respond to IAQ concerns
- what management has done to date (e.g., collecting data, responding to the IAQ problem)
- what management plans to do in order to further investigate and correct the IAQ problem

- the names and telephone numbers of appropriate individuals to call with further questions.

Coordination of staff and occupants

Everything that the building staff and occupants do can impact building air quality. For example:

- use of office supplies (white out, markers, adhesives)
- use of cleaning supplies
- construction activities
- building and equipment maintenance
- food and beverage preparation

Staff and occupants must be informed about the potential impact their activities can have on indoor air quality. Activities that impact IAQ should be reviewed by the IAQ Manager to determine whether the activity is necessary or if the activity can be modified to reduce its impact on IAQ.

Prior notification of building occupants and staff is recommended when activities that affect air quality are necessary. The notification of the planned activity should include the anticipated date and time of the activity, possible IAQ concerns the occupants may experience, the procedures being utilized to minimize IAQ problems, and name and telephone number of individuals to call with further questions.

Renovation and remodeling

As with staff and occupant activities, renovation and remodeling projects can cause IAQ concerns. Activities such as demolition, removal of carpeting, surface finishing, and new furniture installation can cause immediate or delayed problems for building occupants.

Renovation and remodeling plans should be carefully scrutinized for impact on IAQ. Once the project has begun, IAQ concerns should be discussed during the weekly construction progress meetings. Alternative work practices to minimize construction impact on IAQ can include:

- modification of the building HVAC system to isolate construction areas from occupied areas
- schedule construction activities expected to significantly impact IAQ during non-business hours
- utilize local exhaust ventilation
- relocation of building occupants and staff

When alternative work procedures or schedules are not reasonably feasible, building occupants and staff should be notified of possible air quality problems in advance of the activity. The notification of the planned activity should include the anticipated date and time of the activity, the possible IAQ problems the occupants can expect, the procedures being utilized to minimize IAQ problems, and name and telephone number of individuals to call with further questions.

Renovation and remodeling may also create building conditions that can lead to IAQ problems. Section 1 of Appendix A, Design Parameters, identifies HVAC system and building design criteria that require attention to IAQ issues during the project design phase. These parameters should be provided to anyone performing design services for state agencies. The IAQ Manager should verify that the design parameters are being achieved.

Contracted services

Services provided by outside vendors should also be reviewed for potential impact on air quality. Common services that are of particular concern are pest control, equipment maintenance and janitorial services. When alternative work procedures or schedules are not reasonably feasible, building occupants and staff should be notified of possible air quality problems in advance of the activity as discussed above.

Buildings with occupants susceptible to the accumulation of dust or other allergens may require the development of specialized cleaning procedures or equipment (e.g., HEPA filtered vacuums).

Periodic building inspection

Periodic review of the existing building conditions may identify potential IAQ problems before the development of concerns by building occupants. The IAQ Manager should tour the building on a routine basis (e.g., monthly) to check for the following items:

- water damaged ceiling, wall, and floor finishes - these areas can act as a growth site for microorganisms
- dust streaking near air diffusers - may indicate a breach in the filtration system or inadequate filtration
- mold growth on building components - may cause allergic reactions in occupants
- building use changes - changes may affect ventilation, temperature, and humidity control
- lingering odors - could be an indicator of insufficient ventilation
- outside air dampers - insure that they are functioning
- air filters - confirm replacement schedule is being followed

IAQ concern response and communication

Prompt response to the IAQ concerns of building occupant is imperative. Following the receipt of an IAQ concern, the IAQ Manager should:

- identify the extent of concern - is the situation isolated to an area or individual
- identify and correct cause of the problem if determinable
- discuss IAQ concern with building engineer and management
- if cause is not determinable conduct periodic building evaluation (as discussed earlier) and review the HVAC maintenance recommendations identified in Appendix A.
- consult with the DOER Industrial Hygienist
- distribute and collect IAQ questionnaire (can be found in the appendices of Appendix A) on behalf of the DOER Industrial Hygienist

- coordinate site investigation with the DOER Industrial Hygienist
- communicate status of IAQ investigation with building occupants and management

Conducting an Indoor Air Quality Investigation

Investigation approach

Investigation of indoor air quality problems is not an easy job. These problems can be very complicated due to highly charged emotions, the complexity of the buildings themselves, and the fact that standard epidemiology and industrial hygiene evaluation techniques may be inconclusive.

The Department of Employee Relations, Safety and Industrial Hygiene Unit's approach to investigations of this type follow the methods developed by NIOSH (National Institute for Occupational Safety and Health) in their publication "Guidance for Indoor Air Quality Investigations." The NIOSH technique is probably best described as one of exclusion, by which you try to eliminate and narrow-down the range of possible problem causes. DOER, in conducting indoor air quality surveys, has found six major sources of concerns, these being;

1. Inadequate Ventilation: These problems involve lack of fresh air and/or uneven distribution of fresh air in the building.

2. Temperature and Humidity: These problems involve temperature and humidity levels outside of the normal comfort range for workers.

3. Inside Contamination: Copy machines and office products have been identified as the major significant source in many of the investigations.

4. Outside Contamination: This is due to reentrainment of previously exhausted contaminants, generally caused by improper air intake placement or by periodic changes in the wind conditions. One of the most common sources of outside contamination has been vehicle exhaust fumes from parking garages or loading docks being drawn into the building ventilation system.

5. Microbiological Contamination. Generally, this type of problem is associated with cooling coils, cooling coils drainage systems, humidification and adjacent ventilation ductwork contaminated with bacteria, fungi and molds.

6. Building Fabric Contamination. This results from building materials off-gassing, or releasing gasses when the materials are first installed. These problems will resolve with time, generally six months to one year.

Initial IAQ investigation

Typical IAQ initial investigations will include the review of several items including: a visual inspection of the HVAC system, observation of physical conditions in the concern area, interviews with the individuals experiencing concerns, and measurements of air temperature, humidity, carbon dioxide, carbon monoxide, combustible gas, formaldehyde, and hydrogen sulfide throughout the concern and non-concern areas. Chapter 6 of Appendix B details the steps in diagnosing IAQ concerns. The following is a brief discussion of the preliminary sampling methods and the recommended standards for various indoor air properties.

Temperature and humidity

There is no single "ideal" temperature and humidity level suitable for all building occupants. However, ASHRAE recommends that temperatures in the winter be in the range of 68 - 76 degrees with a relative humidity level of 30 - 60 percent. Summer ranges should be 72 - 80 degrees with a relative humidity level of 30 - 60 percent. These ranges should obtain thermal acceptability of sedentary or slightly active persons.

In Minnesota the indoor temperatures during the summer within conditioned buildings should be 72 - 76 degrees. Temperatures within the ranges 68 - 72 and 76 - 78 degrees are considered borderline with temperatures over 78 or below 68 unacceptable. In the fall, winter and spring the indoor temperature should be 70 - 74 degrees. Temperatures within the ranges 68 - 70 and 74 - 76 are considered borderline with temperatures below 68 or over 76 unacceptable. Relative humidity levels should range from 30 - 60 percent year round. Levels below 20 percent in the winter and above 60 percent in the summer should be considered unacceptable.

Concerns regarding temperature and humidity can be caused by:

- poor thermostat location
- solar radiation
- improperly designed HVAC system
- restricted air flow patterns
- excessive personnel or equipment loading
- excessive outdoor air introduction
- renovated spaces

DOER uses a TSI model 8550 or 8551 Q-trak direct reading meter to take spot measurements of temperature and humidity. This device also allows data-logging which allow the tracking of temperature and humidity over time.

Carbon dioxide levels

Carbon dioxide is a normal constituent of exhaled breath and can be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area. The outdoor, ambient concentration of carbon dioxide is usually 300 - 425 ppm (parts per million). Usually the carbon dioxide level is higher inside a building than outside, even in buildings with few complaints about indoor air quality. However, if indoor carbon dioxide concentrations are more than 1000 ppm (3 to 4 times the outside level), there is probably a problem of inadequate ventilation and complaints such as headaches, fatigue and eye and throat irritation are frequently found to be prevalent.

The carbon dioxide itself is not responsible for the complaints. However, a high concentration of carbon dioxide may indicate that other contaminants in the building may also be increased and could be responsible for occupant complaints.

Well ventilated buildings should have carbon dioxide levels in the range of 600 - 1000 ppm with a floor or building average of 800 ppm or less. If average carbon dioxide concentrations within a building are maintained below 800 ppm, with comfortable temperature and humidity levels, complaints about air quality should be minimal. If carbon dioxide levels are greater than 1000 ppm, widespread complaints may occur and thus 1000 ppm should be used as an upper limit guideline. This does not mean that if this level is exceeded the building is hazardous or that it should be evacuated, but rather this level should be a guideline that helps maximize comfort for all occupants.

The recommended ventilation requirements per occupant are lower in classrooms than in office areas. Acceptable carbon dioxide levels for classrooms are levels of 800 - 1200 ppm with a daily average less than 1000 ppm. Carbon dioxide levels in excess of 1200 ppm, in classrooms, are unacceptable and action should be taken to increase the supply of fresh air under these conditions.

Two organizations have mandatory requirements for fresh air in office areas, the State of Minnesota Building Code (applies to all cities with a population over 2500 and to all areas of 12 counties) and the Minnesota Occupational Safety and Health Regulations (MnOSHA) which apply statewide. These requirements apply to all new buildings and older buildings which have major renovations to their heating, ventilation and air conditioning systems.

Minnesota State Building Code - ASHRAE developed a guide regarding outdoor fresh air requirements in buildings in 1973. This guide was adopted by the State of Minnesota Building Code in 1976 and was the standard until May, 1991, when ASHRAE 62-1989 became the enforceable standard. The ASHRAE 62-1989 requirements apply to all buildings built after May, 1991, and older building which have major renovations to there heating, ventilation and air conditioning systems.

The standard prior to May, 1991, 7 1/2 cfm (cubic feet per minute) of outside air per occupant. There are different ventilation requirements for other types of occupied spaces such as classrooms, conference rooms etc.

After May, 1991, the code requirements (ASHRAE 62-1989) require 20 cfm of outside air per expected occupant in office areas, conference rooms, and 15 cfm per expected occupant in reception areas and classrooms.

Minnesota Occupational Safety and Health (MnOSHA) - These standards, which were adopted from the Minnesota Industrial Commission in 1972, regulate the amount of fresh air that must be provided and distributed in all workrooms. This is covered under Minnesota Rules 5205.0110. "Workroom Ventilation and Temperature." These regulations state the following:

Subpart 1. Air. Air shall be provided and distributed in all workrooms as required in this code, unless prohibited by process requirements. Outside air shall be provided to all workrooms at the rate of 15 cubic feet per minute per person.

Buildings complying with the MnOSHA regulation should maintain the carbon dioxide concentration in occupied spaces (where the source of the carbon dioxide is people's exhaled breath) below an average of 1000 ppm.

In building areas where there are sources of carbon dioxide besides exhaled breath, the above guidelines cannot be used. Other sources can include exhaust gas from kilns, internal combustion engines, dry ice etc. Under these conditions the OSHA standard on carbon dioxide must be used to determine whether adequate fresh air is being provided. The OSHA standard on carbon dioxide is an 8-hour time weighted average of 10,000 ppm with a short term 15 minute average limit of 30,000 ppm.

If elevated carbon dioxide levels are detected, the most likely cause is inadequate outside air being supplied to the space. This lack of ventilation can be caused by:

- closed or malfunctioning outside air dampers
- variable-air-volume HVAC system with improper minimum settings
- presence of a combustion source in the space

DOER utilizes a TSI model 8551 or 8550 Q-trak direct reading monitor to measure carbon dioxide levels. Detector tubes can also be used to determine carbon dioxide levels.

Carbon monoxide levels

Carbon monoxide is a normal constituent of exhaust gases from internal combustion engines and cigarette smoke. For office areas, levels of carbon monoxide are normally in the 1 to 5 ppm range and should not exceed 9 ppm.

Occupant symptoms including headaches, drowsiness, and nausea in areas where there is a combustion source or possible contamination from an outdoor combustion source indicate a potential carbon monoxide exposure.

Carbon monoxide levels are measured by DOER with either a Draeger model 190 Data-logger or a TSI model 8551 Q-trak IAQ Monitor. Both instruments are direct reading monitors with data-logging capabilities. Detector tubes can also be used to determine carbon monoxide levels.

Combustible gas

Natural gas or methane is a normal and combustible constituent of sewer gas. Methane is a colorless odorless gas which is not toxic if inhaled but instead is primarily an explosion hazard. Combustible gas is measured in percent of the lower explosive limit (%LEL). An air and combustible gas mixture at 100 percent LEL can explode if a spark is present. Combustible gas is considered hazardous if the level exceeds 10% LEL.

A Gastech model GX-82 is used by DOER to measure combustible gas levels in the space. The Gastech instrument measures combustible gas which could be present in the air but does not perform any type of identification of the combustible gas which is present.

Hydrogen sulfide

Hydrogen sulfide is a normal constituent of sewer gas. Hydrogen sulfide is a colorless gas that smells like rotten eggs. The odor threshold (the level at which people can first smell the gas) is 0.001 ppm. OSHA has established a ceiling exposure level for hydrogen sulfide of 20 ppm. The American Conference of Governmental Industrial Hygienists (ACGIH) currently recommends an 8-hour TWA of 10 ppm and a 15 minute TWA of 15 ppm.

Sources of hydrogen sulfide in buildings usually arise from dry drain traps or broken sewer lines. Maintenance staff should pour water down drains as part of a preventative maintenance program.

DOER uses a Gastech model GX-82 instrument to measure hydrogen sulfide levels in the environment. Detector tubes can also be used to determine hydrogen sulfide levels.

Formaldehyde levels

Formaldehyde is a common constituent of various adhesives used in particle board, carpet and furniture. The use of formaldehyde has been modified in recent years to reduce its release from newer office furnishings. Increased ventilation following renovation projects should minimize the effects of "off-gassing" by new products.

For office areas, levels of formaldehyde should not exceed 0.1 ppm. DOER utilizes Draeger Detector Tubes to measure formaldehyde levels.

Visual inspection of the HVAC system - The following items should be evaluated during an IAQ survey:

Outside Air Intake Location - The relative location of the outside air intakes to contamination sources should be reviewed. Examples of sources of contamination include vehicle exhaust, various building exhausts, trash collection locations, and cooling towers.

HVAC System Filtration - The type of filtration used in the HVAC system should be determined. The manufacturer generally can supply the filter efficiency information; however, one must know the test method used for determining the efficiency. Most filters are rated by ASHRAE Standard 52.1-1992. The minimum recommended filtration for office environments is a pleated, extended surface filter with a dust spot efficiency rating of at least 25-35%. Please refer to Appendix A, pg. 2.12-2.14 for a detailed discussion on filtration.

Cleanliness of Cooling and Heating Coils and Drain Pan - These areas should be visually inspected for the presence of accumulated dirt and debris. Also, the cleanliness of the drain pan should be determined visually and whether the condensate water can drain from the pan. Review the frequency of cleaning for these areas. Please refer to Appendix A, pg. 2.14 - 2.16 for a detailed discussion on these areas and recommended cleaning schedule.

Condition of Ductwork Adjacent to the Cooling Coils - A visual inspection of the HVAC ductwork within 10 feet upstream and downstream of the cooling coils or humidification systems should be conducted. Things to look for are dust, mold, and water accumulation in the ductwork which indicate potential problems. Please refer to Appendix A, pg. 2.9 - 2.11 for a detailed discussion.

Building inspection

A general walk through evaluation of the building condition is performed noting specifically:

- water damaged ceiling, wall, and floor finishes
- dust streaking near air diffusers
- mold growth on building components
- apparent building use changes
- lingering odors outside air dampers
- air filtration

Operation of Buildings for Good IAQ

Effective management of IAQ requires the implementation of a feasible Operations and Maintenance (O&M) program. The specific items to be included within an O&M program are detailed in Section 2 of Appendix A. The following activities calendar outlines O&M program requirements specific to HVAC equipment. Similar calendars can be created for the entire O&M program. The recommended O&M requirements could also be incorporated into your agency's Preventative Maintenance program.

HVAC Maintenance Checklist/Calendar

HVAC Components	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A. Outdoor Air Intake	X	X	X	X	X	X	X	X	X	X	X	X
B. Exhaust Air Outlet	X	X	X	X	X	X	X	X	X	X	X	X
Check Belt Tension			X			X			X			X
C. HVAC Ductwork			X						X			
D. Air Handling Unit												
D.1. Air Filters			X			X			X			
D.2. Heating Coils			X									
D.3. Cooling Coils			X						X			
D.4. Humidifier			X						X			
D.5. Supply Fan			X									

State agencies are in custodial control of thousands of state-owned buildings, and lease hundreds of spaces throughout the State of Minnesota. A number of those buildings have had complaints about the quality of the indoor air. That number has steadily increased over the last few years. The Department of Administration formed the Indoor Air Quality Task Force with the charge of developing guidelines to prevent the development of additional air quality problems, and to assist in mitigating existing problems. The completed guidelines will be used to prepare training packages for dissemination to state personnel.

The Task Force involves eight state agencies whose members include department managers, mechanical engineers, industrial hygienists, an indoor air quality specialist, safety administrators, a building code expert, and a facility manager.

The BUILDING AIR QUALITY manual is a set of guidelines for a safe and healthy environment in state-owned and leased buildings. The manual is divided into three sections; DESIGN PARAMETERS, OPERATIONS/MAINTENANCE, and COMPLAINT RESOLUTION. The guidelines can be applied to renovation, remodeling, and new construction. Managers at all levels may use the complaint process to identify and mitigate problem areas. Building operators may use the information in their current maintenance schedules to prevent problems from occurring.

The Design Parameters section sets forth mechanical requirements for the construction of new buildings and for major renovation or remodeling of existing buildings.

The Operations/Maintenance section has the minimum operating requirements for janitorial services, pest management, mechanical system maintenance, temperature and humidity control, and hazardous materials.

The Complaint Resolution section outlines a process for complaint delivery, handling and final disposition.

Design Parameters

Operations and Maintenance

State of Minnesota Guidelines for Managing Indoor Air Quality Close window

Operations/Maintenance

1. Purpose

To specify minimum acceptable operation and maintenance procedures to provide acceptable indoor air quality (IAQ) in buildings.

2. Scope

These guidelines apply to all state-owned and leased buildings.

3. Managing buildings for good indoor air quality

The relationships among building owners, management, staff and occupants are an important factor in decisions that affect indoor air quality. The objectives of the major players in these relationships may be very different. Occupants want the building to be pleasant, safe and attractive and they want to get the maximum use out of the space they rent, for the least cost. Private building owners and management want to maintain a reputation for providing quality property at reasonable cost, but also need to derive a profit. Building maintenance staff are often caught in the middle, trying to control operating and maintenance costs, while still keeping the occupants satisfied.

Building occupants, staff and management share the goal of providing a healthy indoor environment. Recognition of this common goal may help avoid conflict when discussing many of these issues.

Any building management system will only be successful if it is organized to fit the specific building. This manual's main purpose is to provide specific guidelines to building owners and facility managers in how to operate a building with acceptable indoor air quality for building tenants.

Managing a building for good indoor air quality involves implementing the procedures outlined. All buildings are different and changes will need to be made to these procedures to customize them for each building.

Indoor air quality management will be facilitated if one individual is given overall responsibility for IAQ. This individual should have a good understanding of the building's structure and function and should be able to communicate with tenants, facility personnel and building owners. The IAQ manager should have the following responsibilities:

A. Establish a communication system with occupants about IAQ issues.

B. Coordinate staff efforts that affect indoor air quality and make sure that staff have the information and authority to carry out their responsibilities.

C. Review all major remodeling or renovation projects in the building for their IAQ implications.

D. Reviews contracts and negotiates with contractors (cleaning services, pest control) whose routine activities in the building could create IAQ problems.

E. Periodically inspect the building for indicators of IAQ problems.

F. Respond to complaints or observations regarding potential IAQ problems.

G. Conduct an initial walk through investigation of any IAQ complaints.

4. Janitorial services/housekeeping

Janitorial and housekeeping services are very important to the health and appearance of a building. Different surfaces in a building require regular cleaning. Fleecy materials such as carpet, ceiling tiles, wall dividers and upholstery will become sinks or reservoirs where microorganisms accumulate (For example - dust mites). The presence of dirt and debris in fleecy microenvironments provides extensive adsorptive or absorptive surfaces for uptake of moisture that can support growth. Dust mite allergens are not effectively controlled by any form of dilution ventilation. Because dust mite allergens do not remain airborne for long periods (particle size > 10 microns), control by ventilation alone is impractical. Reducing the potential for these problems requires reduction of microbial nutrients in buildings, by installing more efficient filters and by more efficient cleaning of the work surfaces.

Hard surface floors (vinyl or ceramic) are recommended within 50 feet of the entrances to buildings. Lunchrooms, break areas, kitchen areas and high traffic hallways also should have this type of floor material. Carpet is not desirable in these areas because of the high potential for the floor areas to become heavily soiled and the difficulty with cleaning heavily soiled carpet versus a hard surface floor.

At entrances to buildings, nonporous surfaces covered with properly selected entry mats are recommended. Entry mats are needed to collect or adsorb soil and moisture from peoples shoes, when they enter the building. The number and type of mats will vary depending on the volume of traffic into and out of the building.

A. Carpet Maintenance and Cleaning

1. Weekly Routine Carpet Maintenance

a. Controlling Soil - Most abrasive particle soil accumulates initially within the first few feet of major entries to buildings. Once inside, this soil takes its toll on carpet fibers, and on the general appearance of the structure. It also contributes airborne particles that affect overall indoor air quality. Every effort should be made to keep this soil accumulation outside by the use of properly selected entry mats. Mat selection (type and size) must consider the type and amount of soil exposure and the number of people using a structure.

Entry mats to collect or absorb soil and moisture are to be placed prior to carpeted areas in entries of buildings and not on top of carpet. They must be maintained by weekly vacuuming, shaking and cleaning, or with weekly exchange by mat rental or cleaning companies. These entry mats are to be vacuumed weekly and cleaned (hot water extraction) monthly.

b. Vacuuming Carpet - Routine vacuuming with properly maintained, quality equipment is the single most important step to prolong the life and appearance of carpet. A top-fill upright vacuum with brush agitation or a canister vacuum with a power head incorporating brush agitation should be selected and used with frequency. Equally important, soil that is loosened and vacuumed from carpet must be collected in the vacuum's recovery system and not allowed to re-enter the air within the structure to contribute to indoor air pollution. For this reason, a high efficiency filtering system, vacuum cleaner bags with a minimum rating, of 90 percent efficient for 1 micron size particles, need to be used in any vacuum equipment employed.

c. Immediate Spotting - Most spots can be removed easily if the excess is lifted or blotted and treated immediately with plain water or with spotters containing mild (pH range of 5-9) dilute detergents that do not leave residue. If ignored those spots or components thereof, may bond with fiber dye sites, forming permanent stains. Immediate spotting is an essential responsibility for cleaning staff.

2. Carpet Dry Chemical/Foam/Shampoo/Steam(Hot Water) Cleaning

a. Cleaning Frequency - Commercial carpet should be analyzed according to its construction, the type and frequency of traffic, the soiling conditions encountered, and other extenuating circumstances, such as occupant activities, structure design and indoor air quality. Specialized maintenance and cleaning programs (e.g. weekly, monthly, quarterly, semi-annually) should be developed based on individual needs.

Frequent cleaning of exterior entrances and high traffic areas reduces the contaminants and soil particulates from outside the structure that accumulate in these areas.

Carpet Cleaning Guidelines is intended to serve as a guideline for recommended cleaning frequencies for carpet. Carpet Cleaning methods must follow the International Institute of Carpet and Upholstery Certification (IICUC), 2715 East Mill Plain Blvd., Vancouver, Washington 98661, 206/693-5675, Carpet Cleaning Standard S001-1991.

Carpet Cleaning Guidelines

- Environment Recommended Guideline
- Day Care Center 2 weeks
- Nursing Homes 1 month
- Office Building - Ground Floor 2 - 6 Months
- Office Building - Higher Floors 6 - 12 Months
- Classrooms 2 - 6 Months
- Food Service Areas 1 month

B. Wall Dividers

Wall dividers which are used to separate work areas may also contribute to poor air circulation and become sinks or reservoirs where microorganisms accumulate.

Wall dividers used in open bay areas should normally be less than 67 inches tall. The dividers should have a 1 to 4 inch opening at the bottom and the top of the divider should not be closer than 36 inches to the ceiling. Dividers which are closer than 36 inches to the ceiling tend to interfere with air flow from ceiling air diffusers. Openings at the bottom are desirable to allow air to freely circulate more efficiently. Wall dividers over 67 inches tall normally do not improve noise control but do interfere with air flow.

Fleecy wall dividers should be analyzed according to its construction, the type and frequency of traffic, the soiling conditions encountered, and other extenuating circumstances, such as occupant activities, structure design and indoor air quality. Specialized maintenance and cleaning programs (e.g. monthly, quarterly, semi-annually) should be developed based on individual needs. At a minimum these wall dividers need to be vacuumed with quality equipment at least annually. This cleaning will also prolong the life and appearance of these dividers.

Routine vacuuming with properly maintained, quality equipment is the single most important step a business owner/manager can take to prolong the life and appearance of these dividers. A top-fill upright vacuum with brush agitation, or a canister vacuum with a "power head" incorporating brush agitation should be selected and used with routine frequency. Equally important, soil that is loosened and vacuumed from dividers must be collected in the vacuum's recovery system and not allowed to re-enter the air within the structure to contribute to indoor air pollution. For this reason, a high efficiency filtering system, vacuum cleaner bags with a minimum rating, of 90 percent efficient for 1 micron size particles, need to be used in any vacuum equipment employed.

5. Components of heating, ventilating and air conditioning (HVAC) systems

All occupied buildings require a supply of outdoor air. Depending on outdoor conditions, the air may need to be heated, cooled or humidified before it is distributed into the occupied space. As outdoor air is drawn into the building, indoor air is exhausted or allowed to escape, thus removing air contaminants. The term "HVAC system" is used to refer to the equipment that can provide heating, cooling, humidification and filtration of indoor and outdoor air to maintain comfortable conditions in a building. Not all HVAC systems are designed to accomplish all of these functions. Some buildings rely only on natural ventilation (leakage though windows, doors and walls). Others lack mechanical cooling equipment and many function with little or no humidity control. The features of the HVAC system in a given building will depend on several variables, including:

1. age of the design
2. building codes in effect at the time of the design
3. budget that was available for the project
4. planned use of the building
5. owners' and designers' individual preferences
6. subsequent modifications

HVAC systems range in complexity from stand-alone units that serve individual rooms to large, centrally controlled systems serving multiple zones in a building.

The components of a typical building ventilation system which is using a forced air HVAC design are discussed below:

A. Outdoor Air Intake - This intake is the fresh air supply for a building. This supplies outdoor air to the outdoor air ventilation ductwork.

B. Exhaust Air Outlet - This outlet allows air to escape from the building. The return air ventilation ductwork can be attached to this outlet. In some buildings all the air exhausted from the building occurs in the rest rooms or cafeteria areas of the building and can be a completely separate exhaust system not connected to the main air handling system.

C. Ventilation Ductwork - Air moves though ductwork. Ductwork will have different names depending on where the air is moving to or from. See definitions below.

1. Outdoor Air Ductwork - This ductwork supplies outdoor air to the air handling unit.

2. Return Air Ductwork - This ductwork removes air from the conditioned occupied space and returns the air to the air handling unit which reconditions the air. In some cases some of the air in this ductwork is removed to the exterior of the building.

3. Mixed Air Ductwork - This ductwork mixes air from the Outdoor Air and the Return Air Ductwork and supplies this mixed air to the air handling unit.

4. Supply Air Ductwork - This ductwork supplies air from the air handling unit to the occupied space.

5. Supply Air Inlet (Diffusers) - The supply air inlet (diffusers) allows the air from the supply air ductwork to enter the occupied space.

6. Return Air Outlet - The return air outlet allows air from the occupied space to enter the return air ductwork.

7. Air Dampers - Air dampers, which are found in ventilation ductwork in a number of different places, allows the quantity of air in different parts of the ventilation ductwork, to be adjusted. These dampers in some systems are computer controlled and in other systems can only be manually adjusted. Some dampers are adjusted to balance the system. Some buildings will use outdoor air whenever possible to provide cooling inside the building. These systems will adjust the quantity of outside air automatically as cooling needs change inside the occupied space. As the amount of outdoor air supplied to a building increases, the amount of air exhausted must also increase. Several air dampers are adjusted at the same time in these systems by the computer.

D. Air Handling Unit - The air handling unit is the part of the ventilation system which forces air to move within the ventilation system. This unit also conditions the air by providing heating, cooling, humidification, and filtration of the air streams. The components of the air handling unit are normally located close together in a mechanical room inside a building or on the roof of the building. The components of the air handling units are described below.

1. Air Filtration System - The air filtration system cleans the air of undesirable elements. Most systems remove particulates (dust) from the airstream. These systems can be a mechanical screen (filter) or some type of electronic cleaner or a combination of these two. Airstream filters to remove unwanted gases from the ventilation system are rare because of the difficulty and expense in removing unwanted gases from an air stream.

2. Heating Coils - The heating coils are used to increase the temperature of the airstream in the ventilation system and are normally located downstream of the air filtration system. Heating coils resemble car radiators and have metal fins attached to metal tubes. Hot liquids are pumped though the metal tubes with the attached metal fins. The airstream passes though the coil and picks up heat from the metal tubes in the coil.

3. Cooling Coils - The cooling coils (evaporator coils) are used to decrease the temperature and humidity level of the airstream. During this cooling process, water will condense on to the cooling coils and drip into the drip pan located at the base of the cooling coils. Cooling coils resemble heating coils and are normally located immediately downstream of the heating coils.

4. Humidifier - The humidifier adds moisture to the airstream and is normally located downstream of the cooling coil.

5. Supply Fan or Air Blower - The fan or air blower is the device which forces air to move within the HVAC system. Some HVAC system will have separate return and supply air blowers while other systems will use a single blower or fan to both exhaust and supply air to an occupied space. The supply fan is normally located downstream of the cooling coils, however it can be located anywhere inside the air handling unit.

Figure 2.1 Typical HVAC Air Handling Unit

E. HVAC Maintenance - concerns with each of the HVAC components will be discussed in the following sections. A maintenance check list is also included at the end of this section and in the Appendix of this manual.

Outdoor Air Intake - On a monthly basis:

Inspect intake for blockage

Verify if intake dampener works and is within design specifications

Verify dampener does not close completely

It needs to be determined that the damper does not close completely while the building is occupied.

Normally the minimum fresh air intake setting, while a building is occupied is 15 to 20 percent (15 to 20 percent of supply air to an occupied space is outdoor air) of the total mixed airstream (return air plus outdoor air). During building occupancy the fresh air intake should never be completely closed.

Exhaust Air Outlet - Maintenance includes:

Monthly, tracer smoke should be released in rest rooms and other exhaust points to ensure that air is being exhausted from these.

Quarterly, the belt tension on all fan motors are to be checked for proper deflection (see manufacturer's service manual). Normally the deflection is determined by dividing the belt span distance (in inches) by 64.

HVAC Ventilation Ductwork - Ductwork needs to be inspected on a semi-annual basis. Ductwork inspection should occur when the cleaning of the cooling coils occurs. Ductwork needs to have easy-to-open observation and clean out doors installed at a minimum in the following locations:

a. Clean out door(s) (as large as possible) upstream and downstream of cooling coils to allow maintenance workers good access to clean the ductwork within five feet of the cooling coils, the cooling coils and drainage pans from the cooling coils.

b. Inspections door(s) (minimum 10 inch size) 10 to 20 feet downstream of the cooling coils. If there are several supply air ductwork branches in this area, an inspection door needs to be installed in each branch.

c. Clean out door(s) (as large as possible) at the filtration system for the air handling unit to inspect the ductwork surfaces five feet on each side of the filtration system.

d. Inspection doors (minimum 10 inch size) 10 to 20 feet upstream of the filtration systems. If there are several return and/or mixed air ductwork branches in this area, an inspection door needs to be installed in each branch.

These observation doors (clean out doors) are needed to allow inspection of the condition of the ductwork in these buildings. Things to look for are dust, mold (microbial) and water accumulations in the ductwork which indicate potential problems with the air handling unit.

Standard galvanized ductwork should be cleaned every 20 to 30 years. Cleaning ductwork lined with fibrous glass on the inside is very difficult and should always be approached with caution. This type of ductwork collects dirt very effectively and normally within 10 to 20 years will need to be cleaned and coated or replaced.

Further study is clearly needed to determine proper methods of controlling microbials in existing buildings which have interior fibrous glass duct liners. Some tentative conclusions can be drawn from our efforts so far, these include:

* Cleaning and Fumigation of Interior Fibrous Glass Ductliners - is not effective in controlling microbials. Fibrous glass liners are impossible to clean effectively and dirt (nutrients for the microbes) will always be present in the fibrous glass liners. Regrowth of microbes occurs rapidly under these conditions.

* Cleaning and Removal of Fibrous Glass Duct Liners Down To Bare Galvanized Metal - is effective at controlling microbials. If feasible this is a good approach but has potential to cause problems in many cases. The need for insulation should be evaluated

and the exterior of the duct work insulated if this is necessary. Interior duct liners are used to control noise. Removal of the liner may create a noise concern for building occupants. Ductwork on the exterior of the building envelope will need to be insulated. Some ductwork on the inside of the building envelope will also need insulation to prevent overheating or over cooling of certain areas of the building. This will also be necessary to prevent condensation on the exterior of the duct work in some cases.

Some adhesives used to attach the fibrous glass to the interior of the ductwork are difficult to remove. These adhesives can be nutrients for microbe growth in some cases. If this surface is rough it will likely collect dirt and promote microbe growth on its surface in a manner similar to the original fibrous glass liner.

* Cleaning and Coating Interior Fibrous glass Liners - needs to always be approached with caution because many coatings can be potential nutrient sources for microbe growth.

* Cleaning and Coating with "Foster 40-20" or "Tough-Coat" - does appear to be successful but should be tested further to determine whether these materials will be effective long term (10 - 20 years or longer). The manufacturers' indicate that they have data showing these materials effective for many years. Some of this data would indicate effectiveness which would compare to 80 years of normal use. We have become comfortable with using these materials in building HVAC systems. Coatings need to be selected with extreme care to assure that the coating doesn't create additional hazards for the occupants. To date we have had success with only two coatings. The two coating are:

"Foster 40-20" is manufactured by the Foster Products Corporation, An H.B. Fuller Company. This product is EPA registered as a long term fungicidal protective coating for use on the interior of HVAC duct systems.

"Tough-Coat" is distributed by VAC System Industries, Apple Valley, Minnesota. "Tough-Coat" is a polyacrylate copolymer emulsion coating.

Coating interior fibrous glass liners has been difficult in the past and should always be approached with caution. Cleaning and coating ductwork with interior fibrous glass liners is highly specialized work and should be only attempted by properly trained workers. Fibrous glass liners which are not firmly attached can not be coated because the coating may cause the liner to fall off. In some cases the only option is to remove the interior liner to bare metal or to cover over the liner with galvanized metal. Removal of the liner in some cases is very difficult because of the adhesives used to attach the fibrous glass. Some of these adhesives, if exposed, may become food for the mold. Coating the adhesive and reinsulating on the exterior of the ductwork is an option in these cases.

The goal in high moisture area, ductwork within ten feet upstream and downstream of the cooling coils, is to provide a washable impermeable surface. Normally two to three coats is necessary in areas near the cooling coils. Ductwork located more than ten feet from the cooling coils will only need one coat. These coatings can not be used in the bottom of the drainage pan.

Cracks or tears in the fibrous glass within ten feet of the cooling coils need to be repaired by first painting the surface of the cracks with a coating and then placing a seam tape of polyester material over the crack and then painting over the polyester material. We have been using a material called CST-100 seam tape manufactured by Oregon Research and Development Corporation which is 4 inches wide and 100 feet long. This material is also available in a larger size which is 42 inches wide and 100 feet long for covering wide areas if needed. Both of these are available from Oregon Research & Development Corporation, 1920 McGilchrist S.E., Salem, Oregon 97302-1561 phone number (503) 588-7000. In the Twin Cities area this material is available at Knox Lumber Stores and is typically used with a roofing material called "Snow Roof".

Cracks or tears in the fibrous glass liner which are further than ten feet from the cooling coils normally will not need to be repaired before coating occurs.

4. Air Handling Unit (ahu) - The components of the air handling unit need inspection on a regular basis. Many parts will need servicing and lubrication on a weekly basis to assure that the unit is mechanically sound. This regular maintenance will vary greatly in the different types of air handling units. Service manuals for each air handling unit should be consulted for maintenance

schedules on this. The discussion below concerns regular maintenance to components which is necessary to prevent indoor air quality concerns.

a. Air Filtration System - Filters are primarily used to remove particles from the air. The type and design of a filter determine its efficiency at removing particles of a given size and the amount of energy needed to pull or push air through the filter. Filters are rated by different standards and test methods such as dust spot and arrestance which measure different aspects of performance. Most filters are rated by ASHRAE Standard 52.1-1992.

Low efficiency filters (ASHRAE Dust Spot ratings of 10-20 percent or less) are often used to keep lint and dust from clogging the heating and cooling coils of a system. In order to maintain clean air in occupied spaces, filters must also remove bacteria, pollens, insects, soot, dust and dirt with an efficiency suited to the use of the building. Using high quality filters is one of the best insurance policies for the good health and energy efficiency of an air handling system.

All dirt cannot be eliminated from the HVAC system; however, the amount of dirt present inside the HVAC system can be controlled by proper air filtration.

The quality of filters used in buildings varies greatly. The three most common filter media are the following:

1. Unrated filters - Filter efficiencies are not typically known but are very low (less than 1 - 15 percent dust spot efficiency in most cases). These filters may be tested for percent arrestance using the ASHRAE standard 52.1-1992. These types of filters are designed to be prefilters and if used for this purpose are acceptable. About 50 percent of the problem buildings we have surveyed use these types of filters as the only filtration media and about 10 percent of the buildings inspected have filters improperly installed and/or have no filters at all. Under these conditions, large quantities of dirt will be present inside the HVAC system. These types of filters/systems are not recommended for office buildings. These filters may be used as prefilters but should never be the only type of air filtration in the building.

2. 25 - 35 percent efficient filters - These filters are typically called pleated filters and their collection efficiency is certified by the manufacturer using the ASHRAE Standard 52.1-1992 Atmospheric Dust Spot Efficiency Test. These filters are very effective at filtering dirt out of return and outdoor air streams and have been used in about 40 percent of the buildings we have surveyed. It is the lowest quality filter we recommend to use in an office building. Normally these filters come in 1, 2 and 4 inch thick sizes with the 2 inch filters used the most often (a 2 or 4 inch thick filter has a lower pressure drop (lower resistance to air flow) then a 1 inch filter). The thicker filters have a lower resistance to air flow and the resistance to air flow increases slower with increasing dirt load then the thinner filters. The normal cost for a typical 20 by 20 inch filter is 2 to 10 dollars.

3. 40 - 85 percent efficient filters - These filters are typically used in health care facilities where very clean air is desired. A large number of new buildings use these filters to improve air quality in buildings.

It is impossible to filter all the dirt out of the air stream and some dirt will always find its way into the ductwork. Better filtration will clearly limit the quantity of dirt (or food) which will be present inside HVAC systems. Most of the filters described above become more efficient at collecting dirt as the filters become dirty; however, their resistance to air flow also increases. Because of this, as the filters become dirtier, air bypass around the filters will become more pronounced with increasing dirt load (air always follows the path of least resistance). Filters need to be changed regularly and this will vary from building to building to some extend. For most buildings a filter changing schedule of three times per year is recommended. Change filters in March or April (clean cooling coils at this time), mid summer, and in September or October (clean cooling coils at this time). For buildings using high efficient bag filters, which have good quality prefilters which are changed three times per year, the bags should be changed every 2 to 3 years.

b. Heating Coils - The heating coils (reheat coils) are used to increase the temperature of the airstream in the ventilation system and are normally located downstream of the air filtration system. In some systems heating coils can be located anywhere in the HVAC system.

Heating coils should be inspected annually for accumulation of debris on the upstream side of the coils. These coils normally need to be thoroughly cleaned every 10 years.

c. Cooling Coils - The cooling coils (evaporator coils) are used to decrease the temperature and humidity level of the airstream. During this cooling process, water will condense on to the cooling coils and drip into the drip pan located at the base of the cooling coils. Cooling coils resemble heating coils and are normally located immediately downstream of the heating coils.

During periods when the humidity levels outdoors are high (outdoor dew points at or above 60 degrees), the relative humidity inside the supply air ductwork in air-conditioned buildings can increase to levels above 70 percent. When outdoor dew points are above 60 degrees, the air entering the cooling coils is dehumidified and water condenses on the cooling coils and is drained away. Air leaving the cooling coils, when the outdoor dew point is above 60 degrees, is typically at a temperature of 50 - 60 degrees with a relative humidity of 90 percent plus. This environment is ideal for microbe growth if a suitable site for growth and a food source exists. There are three potential growth sites in the cooling coil area:

1) The cooling coils - Debris can build up on the coiling coils (especially on the upstream side of the coils) and act as a food source for the microbes.

2) The cooling coils drainage area - Debris can build up in the drainage pans and act as a food source for the microbes to grow in this area. In addition, the debris can block the drainage from the cooling coils and cause water to be sprayed or leaked on to the ductwork downstream from the cooling coils. Drainage systems which are not properly engineered will not drain and will allow standing water to accumulated in the drainage pans and/or adjacent ductwork. All drainage pans need to have a water trap (normally at least 3 inches deep) in the drainage system to prevent air from traveling up the drainage system, aspirating water into the airstream.

3) Ductwork downstream and adjacent to cooling coils - Any ductwork in areas where the relative humidity is greater than 70 percent has a good potential for undesirable microbe growth, if a suitable site for growth and a food source exists. The suitable site in many ventilation systems is the porous fibrous glass lining 10 feet upstream and all areas downstream of the cooling coils which the air has to pass by before being distributed throughout the building. The food source is any dust which travels with the air being circulated in the ventilation system which collects on the fibrous glass lined ductwork. The microbes grow on the dirt which has collected on the fibrous glass liner.

Total elimination of microorganisms from buildings is not possible. The goal of building operations is to keep the population of microorganisms within reasonable levels. All buildings should have easy access "clean out doors" upstream and downstream of cooling coils. The three areas mentioned above need to be cleaned with a cleaning solution in March or April and September or October of each year. This cleaning needs to include ductwork 5 feet upstream and downstream of the cooling coils. This cleaning need only occur in September or October in buildings using high efficient filters, ASHRAE dust spot efficiency greater than 60 percent.

Note: Remove/cover up/coat any fibrous glass interior liners which are present within ten feet upstream and downstream of the cooling coils before cleaning is done in this area. Porous fibrous glass liners are difficult/impossible to clean and should not be present in areas adjacent to cooling coils (see discussion on this in Section 5.E.3. HVAC Ventilation Ductwork).

The Minnesota Department of Administration has been using a cleaning material called Virginia KMP Acti-Klean to clean cooling coils and ductwork. This material is diluted with water 3 to 1 and then is sprayed on to the cooling coils and/or ductwork with a hand sprayer (Hudson 3 gallon sprayer) or a powered washer. The Acti-Klean needs to be allowed to soak in for 1 to 2 hours and then is rinsed off with water. Repeat if necessary. If grease or oil is present the Acti-Klean will not work very well. The grease or oil will need to be removed first using an all purpose cleaner.

Note: Acti-Klean should never be sprayed on to a dry coil and then not rinsed off. This material is very biodegradable and can be a food source for mold. If the cooling coils are operating and wet, Acti-Klean can be sprayed on and the condensate used to rinse it off as the manufacturer recommends.

d. Humidifier - When humidification is needed, it must be added in a manner that prevents the growth of microbiologicals within the ductwork and air handlers. Steam humidifiers are the system of choice. Steam humidifiers should utilize clean steam, rather than treated boiler water, so that occupants will not be exposed to chemicals. Clean steam systems normally use a heat exchanger to convert tap water to steam.

Systems using media other than clean steam must be rigorously maintained in accordance with the manufacturer's recommended procedures to reduce the likelihood of microbiological growth.

Humidifiers are commonly found immediately downstream of the cooling coils. These units need to be cleaned semiannually in a manner similar to the cleaning procedures for the cooling coils. Porous surfaces (fibrous glass liners) should not be located within 10 feet of the humidifier. It is common for humidifiers to drip water on to adjacent surfaces. If these adjacent surfaces are porous materials, mold can readily grow in these areas.

The humidifier and adjacent ductwork surfaces need to be thoroughly cleaned in the fall just before the heating season starts and in the spring at the end of the heating season. The humidifier should be cleaned at the same time that the cooling coils are cleaned and the same methods should be used.

e. Supply Fan or Air Blower - Supply Fans or Air Blowers should be cleaned as a part of the duct cleaning process, see Section 5.E.3. HVAC Ventilation Ductwork. Supply Fans should be thoroughly inspected at least annually for surface debris and general operation.

6. Outdoor air concerns

In the 19th century it was concluded that 30 - 40 cubic feet per minute (cfm) of outside fresh air, per person was needed in a building. In the early 20th century the New York School of Comfort recommended 15 - 20 cfm. Early building codes recommended and/or required 15 - 25 cfm per person.

The criteria for evaluating indoor air quality has changed over the years. Two organizations have mandatory requirements on fresh air in office areas, the State of Minnesota Building Code (applies to all cities with a population over 2500 and to all areas of 12 counties) and the Minnesota Occupational Safety and Health regulations (MOSHA) which apply statewide.

Minnesota State Building Code - ASHRAE (The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.) proposed a guide on outdoor fresh air requirements in buildings in 1973. This guide, with some modifications, was adopted by the State of Minnesota Building Code in 1976 and was the standard until May, 1991 when ASHRAE 62-1989 became the enforceable standard. These new requirements apply to all new buildings and older building which have major renovations to there heating, ventilation and air conditioning systems.

What the old building code, which still applies to most buildings, stated was that the outdoor fresh air requirements for a typical office area should be 7 ½ cfm (cubic feet per minute) of outside air per occupant. There are different ventilation requirements for other types of occupied spaces such as classrooms and conference rooms. Buildings complying with the old code, should maintain the carbon dioxide concentration in occupied spaces (where the source of the carbon dioxide is people's exhaled breath) below an average of 1700 ppm.

The ASHRAE 62-1989 requirements are 20 cfm of outside air per expected occupant in office areas, conference rooms, and 15 cfm per expected occupant in reception areas and classrooms. Buildings complying with these regulation should maintain the carbon dioxide concentrations in occupied spaces (where the source of the carbon dioxide is people's exhaled breaths) under most operating conditions below 800 ppm and under the worst conditions below 1000 ppm.

Minnesota Occupational Safety and Health Regulation (MOSHA) which were adopted from the Minnesota Industrial Commission in 1972, regulate the amount of fresh air that must be provided and distributed in all workrooms. This is covered under Minnesota Rules 5205.0110. "Workroom Ventilation and Temperature". This regulations state's the following:

Subpart 1. Air. Air shall be provided and distributed in all workrooms as required in this code, unless prohibited by process requirements. Outside air shall be provided to all workrooms at the rate of 15 cubic feet per minute per person.

Buildings complying with the MOSHA regulation should maintain the carbon dioxide concentration in occupied spaces (where the source of the carbon dioxide is people's exhaled breath) below an average of 1000 ppm.

The legal ventilation standards which applies to most buildings is the MOSHA standard Minnesota Rules 5205.0110. The goal on ventilation for buildings should be the ASHRAE standard 62-1989.

ASHRAE has related the amount of ventilation in a building to the level of carbon dioxide gas present in the air under proper conditions (buildings must have been occupied for a minimum of 3 - 5 hours before tests are taken and the only source of carbon dioxide in the building is the exhaled breaths of typical office workers). Using the above assumptions, the relationship of fresh air supplied is shown in the following table.

Carbon dioxide is a normal constituent of exhaled breath and can be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area. The outdoor, ambient concentration of carbon dioxide is usually 300 - 425 ppm (parts per million). Usually the carbon dioxide level is higher inside than outside, even in buildings with few complaints about indoor air quality. However, if indoor carbon dioxide concentrations are more than 1000 ppm (3 to 4 times the outside level), there is probably a problem of inadequate ventilation and complaints such as headaches, fatigue and eye and throat irritation are frequently found to be prevalent.

The carbon dioxide concentration itself is not responsible for the complaints. However, a high concentration of carbon dioxide may indicate that other contaminants in the building may also be increased and could be responsible for occupant complaints.

If carbon dioxide concentrations are maintained below 800 ppm, with comfortable temperature and humidity levels, complaints about air quality should be minimal. If carbon dioxide levels are greater than 1000 ppm, widespread complaints may occur and thus 1000 ppm should be used as an upper limit guideline. This does not mean that if this level is exceeded the building is hazardous or that it should be evacuated, but rather this level should be a guideline that helps maximize comfort for all occupants. When levels exceed 800 ppm the levels are considered elevated and additional fresh air should be introduced into the building. Levels in excess of 1000 ppm are unacceptable and action should be taken to increase the supply of fresh air into the building. Well ventilated buildings should have carbon dioxide levels in the range of 600 - 1000 ppm with a floor or building average of 800 ppm or less.

The recommended ventilation requirements per occupant are lower in classrooms then in office areas. Acceptable carbon dioxide levels for classrooms are levels of 800 - 1200 ppm with a daily average less than 1000 ppm. Carbon dioxide levels in excess of 1200 ppm, in classrooms, are unacceptable and action should be taken to increase the supply of fresh air under these conditions.

In building areas, where there are sources of carbon dioxide besides peoples exhaled breaths, the above guidelines can not be used. Other sources can include exhaust gas from kilns, internal combustion engines, and dry ice. Under these conditions the OSHA standard on carbon dioxide needs to be used to determine whether adequate fresh air is being provide. The OSHA standard on carbon dioxide is an 8-hour time weighted average of 10,000 ppm with a short term 15 minute average limit of 30,000 ppm.

The overall building air exchange rate (air changes per hour) can be determined based on the drop off rate of carbon dioxide concentration in an unoccupied building (most office buildings become essentially unoccupied after 5:00 p.m. at night). This can be determined using an equation developed by Andy Persily, US National Institute of Standards and Technology, Indoor Air Quality Division, Building 226, Room A-313, Gaithersburg, MD 20899, 301/975-6418. Mr. Persily used the following equation to determine the air exchange rates for building based on carbon dioxide drop off rates:

$C(t) = Co + G/Q + (C(0) - Co - G/Q)e\text{-}It$

This equation assumes the following: ideal air mixing conditions, a constant outdoor carbon dioxide level and a constant inflow of outdoor air into a building.

The above equation can be solved for "I" which is the building air exchange rate. This equation is:

I = - ln[(C(t) - Co)/C(0) - Co)]/t

where

C(0) = indoor CO_2 concentration at the start time interval t=0

C(t) = indoor CO_2 concentration at the finish time interval t

Co = outdoor CO_2 concentration

I = building air exchange rate per hour (ach)

t = time interval between C(0) and C(t) expressed in hours

G = CO_2 generation rate in the building (This is equal to zero if the building is empty or not occupied during this time interval)

Q = air flow in cubic feet per minute (cfm) of outdoor air into the building

ln = natural logarithm

e = base of natural system of logarithms

7. Temperature concerns

The sense of thermal comfort (or discomfort) results from an interaction between temperature, relative humidity, air movement, clothing, activity level and individual physiology. Temperature and relative humidity measurements are indicators of thermal comfort.

Temperature and humidity directly affect thermal comfort. There is considerable debate among researchers, indoor air quality professionals and health professionals concerning recommended levels of relative humidity; however, the humidity levels recommended by different organizations generally range between 20 and 60 percent relative humidity.

The relative humidity levels inside office buildings in Minnesota during the spring, summer and fall tends to be in the range of 30 - 60 percent and will vary depending on outdoor humidity levels. In the winter months the relative humidity levels vary a great deal and are normally in the range of 5 - 40 percent in buildings which do not humidify the air. In building which humidify the air the relative humidity levels are normally in the 20 - 40 percent range.

In Minnesota, it is recommended that summer temperatures should be 72 - 78 degrees with a relative humidity of 20 - 50 percent. The fall, winter and spring temperatures should be 70 - 74 degrees with a relative humidity of 20 - 50 percent.

Relative humidities in excess of 50 percent can potentially cause bioaerosol problems (growth of fungi, molds, bacteria, pollen) with building materials or office furnishings in the occupied space.

Humidity control is very important in office buildings. In building which do not control humidity, the relative humidity can vary significantly from week to week and from season to season. This is especially true in the summer months when the indoor relative humidity in many buildings can vary from 20 to 80 percent from day to day or week to week depending on the outdoor humidity level. People frequently become uncomfortable because of the changing humidity levels and will be constantly adjusting the thermostat up when the humidity level is low and down when the humidity level is high. Humidity levels can be better controlled by changing how HVAC systems operate. This is discussed in greater detail in the DESIGN PARAMETERS section of this manual under Part C. HVAC SYSTEM DESIGN CRITERIA.

ASHRAE published an article titled "The Impact of Comfort Control on Air Conditioner Energy Use in Humid Climates" by (H.I. Henderson, Jr. P.E. et. al. 1992, ASHRAE Technical Data Bulletin Volume 8, Number 3), which indicates that if the indoor temperature in a building is set on the basis of comfort for the occupants, then controlling humidity can lower the energy costs for a building by 3 percent. This means that relative humidity can be controlled in a building with little or no increase in energy costs when comfort is considered.

8. Hazardous materials

An inventory of all chemicals, which are used in a buildings, needs to be performed. This inventory should include chemicals stored or used in the building for cleaning, maintenance, operations and pest control. MSDS (material safety data sheets) for all chemicals used in the building need to be kept at this location.

A "Chemical Inventory" form is included in the Appendix of this manual which can be used to inventory chemical usage in a building.

Two hazardous materials asbestos and lead require special attention. These materials are discussed further below:

A. ASBESTOS

Asbestos materials have been used extensively in building construction for many years. In buildings, the most common materials to contain asbestos are hot water or steam pipe insulation and sprayed on fire proofing of structural members of the buildings. Vibration dampers in HVAC systems, wallboard, taping compound, floor and ceiling tiles and sprayed-on wall or ceiling coverings also can contain asbestos.

Guidance on asbestos concerns in buildings comes from three sources, Minnesota Occupational Safety and Health Administration (MOSHA), Minnesota Department of Health - Asbestos Abatement Unit, and U.S. Environmental Protection Agency - Asbestos Hazard Emergency Response Act (EPA-AHERA). Under statute, the EPA AHERA rules apply to educational facilities K - 12. However, the AHERA rules specifically address asbestos concerns in buildings and should be used as a guide for dealing with asbestos concerns in buildings.

EPA AHERA rules require basically three things:

1. Specially-trained persons must conduct inspections for asbestos materials in the buildings.

2. A management plan must be developed to control the asbestos problems in the buildings.

3. The removal of asbestos material must be performed by specially-trained persons.

The aspect of the EPA AHERA rules which has the greatest impact on building owners is item B, the management plan.

The tasks and responsibilities under the Management Plan are outlined in the Code of Federal Regulations (CFR) 40 CFR 763.84. There are several parts to a management plan but the section of most interest pertains to the Operations and Maintenance Program (O&M Program).

Specially-trained persons during the inspection process will need to classify different parts of a building based on the types of materials which contain (or don't contain) asbestos. The classification of the building will determine the O&M Program Elements needed. To achieve its objectives, an O&M program should include the following elements:

1. A program for informing building occupants of where asbestos is located and how to avoid contact.

2. Work practices for cleaning the building and minimizing ACM (asbestos containing materials) disturbance during maintenance and renovation.

3. Procedures for cleaning up asbestos fibers after a fiber release episode.

4. Respiratory protection and medical surveillance programs.

5. A training program for maintenance and service workers and requirements for outside contractors.

6. Regular surveillance of the ACM (assessing changes in ACM characteristics).

7. Record keeping

These Elements need to appear in every O&M Program even though the extent of each element will vary from program to program depending on the building and the type and condition of the ACM. Further clarification of elements A, E and F is necessary because of common problems with informing building occupants, training maintenance and service workers and having a regular surveillance program of ACM in buildings which have occurred at other facilities which had asbestos containing materials in their buildings.

Building owners need to have an effective system to inspect buildings' and train workers involved in these buildings. It is recommended that all buildings spaces (and in many cases just certain parts of a building) be classified into one of five classes outlined below. These classifications, will determine the type of O&M Program, which will need to be implemented to have an effective program for training maintenance workers, service workers and building occupants. The clarifications of the elements are outlined in the Classes A through E below.

Class A - This type of building space has no asbestos materials present in the building. Building occupants and maintenance workers in these areas do not need any type of special training. Work within these building spaces would not be restricted and inspection of these area on a routine basis is not required. Most newer buildings (constructed after 1980) would fall into this class.

Class B - This type of building space has no exposed asbestos materials which are likely to be damaged or disturbed by building occupants. Building occupants in these areas do not need any type of special training. Entry into these work spaces would not be restricted and inspection of these areas on a routine basis is not required. Maintenance workers in these areas would need special training if they are likely to disturb the asbestos containing material (ACM) inadvertently in normal maintenance activities. In most cases, the ACM is enclosed above suspended ceilings and/or ceiling, which have asbestos coating on them are greater than 12 feet in height and there would be no reason for building occupants to disturb the ACM. Building occupants do not have any direct contact with any ACM.

Maintenance workers including housekeepers and janitors in these buildings would need to receive asbestos awareness training as outlined in the OSHA Standard 29 CFR 1910.1001. This includes information on what materials in these building contain asbestos. This training should be a part of annual Employee Right-To-Know training. These areas would need to have an annual inspection to determine the condition of the asbestos containing materials.

Class C - This type of work space has limited amounts of exposed asbestos containing materials which building occupants can have direct contact with but the ACM is in good condition. Under normal conditions these materials are not likely to be disturbed. Building occupants and maintenance workers will need asbestos awareness training. Most older classrooms and offices which have exposed pipe lagging and sprayed on materials which are kept in good repair would fall into this class. These areas would need to have an annual inspection to determine the condition of the asbestos containing materials.

Class D - This type of space has exposed asbestos containing materials which are in good condition. Under normal operating conditions these materials can be disturbed by normal maintenance operations. These areas are normally restricted and only building maintenance workers have access. Signs need to be posted in these areas informing workers of the types of materials in these areas which contain asbestos and that only trained personnel be involved in disturbing these materials. The OSHA asbestos warning sign must also be prominently displayed in these areas. All workers in these areas need asbestos awareness training. In addition any workers involved in disturbing ACM or repairing ACM need to receive AHERA O&M or training similar to the course "Safe Handling of Asbestos in Maintenance Operations" offered by the Minnesota Safety Council (612/291-9150).

Class E - This type of space has exposed ACM which are not in good condition and there are no plans to keep these areas uncontaminated. These areas typically are infrequently visited by workers. These areas need to be restricted and locked if at all possible. Regardless of whether these areas are locked, there must be signs posted at all entrances to these areas which state that these areas are contaminated with asbestos and only properly trained workers are to enter. The OSHA Asbestos Warning Sign must also be posted at all entrances to these areas. At a minimum, these workers will need to have AHERA O&M or training similar to the course "Safe Handling of Asbestos in Maintenance Operations" offered by the Minnesota Safety Council. The level of training will depend on the type of work performed in these spaces. When working in these spaces workers must wear respirators and protective clothing suitable for the type of work being performed. Guidelines on this are found in the "Guidelines for Developing an Effective Asbestos Control Plan" put out by the Minnesota Department of Health (612/627-5089).

Maintenance workers who work in buildings and/or areas in Classes B - D would need to always be on the lookout for damaged asbestos containing materials. When damaged material is observed this information needs to be reported to the asbestos manager or building manager who would then make sure the material is cleaned up and/or repaired. On an annual basis buildings in Classes B - D need to be inspected by someone who has received training at a minimum at the level of AHERA O&M or training similar to the course "Safe Handling of Asbestos in Maintenance Operations" offered by the Minnesota Safety Council. The preferred training would be someone who has attended the AHERA course on inspecting buildings for asbestos. The person doing these inspections should not be one of the maintenance workers who works in these buildings but someone else. A formal report on the condition of the ACM is needed.

In addition to the above it is recommended that once every five years the building owner have a licensed BI/MP perform an inspection of the ACM in the areas in classes B - E.

B. LEAD PAINT

The requirements for work with lead depend on the type of facility and the work that is done. Lead paint may be present in housing built prior to 1978; it may have been used in commercial structures built after that date. Lead may also be found in plumbing.

This section does not provide enough information on how to handle lead paint to allow the reader to do the work. Like asbestos abatement, lead paint abatement has become highly specialized and highly regulated. This section is intended only to alert the reader to the requirements.

Any work with lead that exceeds OSHA’s exposure limit or action level requires strict controls. Respirators and protective clothing are needed. Warning signs must be posted. All workers must have received training and medical monitoring for lead.

If lead is a health threat to people, it must be abated. Abatement includes removal of lead-based paint or lead plumbing, sealing lead-based paint behind impermeable covers, or removal of the painted structure (e.g., removing a door frame).

The Environmental Protection Agency (EPA) proposed rules in 1994 requiring certification of lead abatement workers. That standard would require identification and assessment of lead-based paint in housing and in public buildings (offices, schools, hospitals - any place likely to be visited by the public). Identification, assessment, and abatement would have to be done by workers certified by the EPA for that task. EPA-certified personnel would also be required for abatement work in commercial buildings, such as warehouses and garages, and for steel structures such as radio towers. If the buildings are demolished, any work that would damage the lead paint (such as torch cutting on lead-based paint) would have to be done by a certified abatement worker.

Whenever paint is to be removed from facilities which house children and which were built before 1978 (e.g., apartments, day care centers), rules from the Minnesota Department of Health apply. The paint must be checked for the presence of lead. Chemical spot tests using sodium rhodizonate (e.g., LeadAlert, by Frandon) can be used. The paint can also be analyzed by a chemical laboratory (which would analyze a paint chip) or, in place, with an x-ray fluorescence analyzer. If the paint contains lead a contractor licensed by the Health Department must do the abatement work.

The property owner may be required to abate the lead paint if any child or pregnant woman living in the residence has a high blood lead level. The local board of health determines if the lead paint or lead-contaminated dust is a hazard that needs control. The board of health can also decide that children's play areas out-of-doors require abatement.

Abatement work can mean removing the paint or covering the paint with an impervious surface, such as plywood. Repainting the surface or wallpapering over it is not acceptable.

All residents must be notified of the abatement and the schedule for abatement, even if the work will not take place in their rooms. If their living area is to be abated, they must be moved out of the area until the work is complete. Any of their rugs, furniture, or other possessions that could be contaminated with lead must be cleaned and moved out.

Summary

Check for lead based paint or lead-contaminated dust

Determine if abatement is needed

Abatement by licensed contractor, per Health Department and OSHA regulations

Abatement by licensed or certified contractor not yet mandated for structures other than housing for children.

9. Integrated pest management

Integrated Pest Management (IPM) is a coordinated approach to pest control intended to prevent unacceptable levels of pests, while causing the least possible hazard to people, property, and the environment and using the most cost-effective means. IPM uses a combination of methods which include:

* improved sanitation removing food from desks, cleaning

* inspection and monitoring of pest population sites

* managing waste (keeping refuse in tight containers, locating waste containers away from buildings, if possible).

* maintaining structures (fixing leaking pipes promptly, sealing cracks)

* adding physical barriers to pest entry and movement (screens for chimneys, doors and windows; air curtains)

* modifying habitats (removing clutter, relocating outside light fixtures away from doors)

* using traps (light traps, snap traps, and glue boards)

* using pesticides judiciously

An efficient IPM program will integrate pest management planning with preventive maintenance, housekeeping practices, landscaping, occupant education, and staff training.

Pest control activities that depend upon the use of pesticides involve the storage, handling and application of materials that can have serious health effects. Common construction, maintenance practices and occupant activities provide pests with air, moisture, food, warmth and shelter. Caulking or plastering cracks, crevices or holes to prevent harborage behind walls can often be more effective than pesticide application at reducing pest populations to a practical minimum.

Integrated Pest Management is a low-cost approach to pest control based upon knowledge of the biology and behavior of pests. Adoption of an IPM program can significantly reduce the need for pesticides by eliminating conditions that provide attractive habitats for pests.

If an outside contractor is used for pest control, it is advisable to review the terms of the contract and include the principles discuss in this section. The following items deserve particular attention.

A. Pest Control Schedule

Schedule pesticide applications for unoccupied periods, if possible, so that the affected area can be flushed with ventilation air before occupants return. Pesticides should only be applied in targeted locations, with minimum treatment of exposed surfaces. They should be used in strict conformance with manufacturers' instructions and EPA labels. General periodic spraying may not be necessary. If occupants are to be present, they should be notified prior to the pesticide application. Particularly susceptible individuals could develop serious illness even though they are only minimally exposed.

B. Materials Selection, Handling and Storage

Select pesticides that are species-specific and attempt to minimize toxicity for humans and non-target species. Ask contractors or vendors to provide EPA labels and material safety data sheets. Make sure that pesticides are stored and handled properly consistent with their EPA labels. Keep track of pesticides and other chemicals used on a "Chemical Inventory" form. A sample form is found in the Appendix of this manual.

Information on pesticide selection, use and storage is available from several local and national sources. These include: Minnesota Department of Agriculture at 612/297-2746, University of Minnesota Extension Service at 900/988-0500 (cost is $2.99 per call), and the Federal EPA at 800/858-7378 or 800/438-4318.

If only limited areas of the building are being treated, adjust the heating ventilating and air conditioning (HVAC) system so that it does not distribute contaminated air throughout the rest of the building. Consider using temporary exhaust systems to remove contaminants during the work. It may be necessary to modify HVAC system operation during and after pest control activities (e.g., running air handling units on 100 percent outdoor air for some period of time or running the system for several complete air exchanges before occupants re-enter the treated space).

Most building ventilation systems change the air in the occupied spaces six times per hour, however most of this air exchange is recirculated air (air does not leave the building). Normally one air exchange per hour of outdoor air occurs in most well ventilated buildings. To remove 95 percent of the contaminated air from a building requires five exchanges of outdoor air into a building which is about 5 hours of building operation.

10. Renovation, remodeling and redecorating activities

Many indoor air quality problems can be prevented if staff and building occupants understand how their activities affect indoor air quality. Many building tenants may already have a functioning health and safety committee which promotes good working conditions. If so, it is easy to add indoor air quality to their list of concerns. If a health and safety committee does not exist consider establishing one or setting up a joint management-tenant IAQ task force. Whatever its official designation, such a group can help to disseminate information about indoor air quality, bring potential problems to the attention of building staff and management, and foster a sense of shared responsibility for maintaining a safe and comfortable indoor environment.

Renovation, Remodeling and Redecorating Activities have the potential for causing indoor air quality problems. Proper planning is important to minimize potential problems. Keep building occupants informed of the nature of these activities.

The most common concern which occurs during these activities are the release of volatile organic compounds from paint, stain, adhesives, sealants, new carpet and furniture.

If possible these types of activities should occur when the building is not occupied. Many times for a variety of reasons these activities need to occur while the building is occupied.

During these activities, the building operator needs to increase the fresh intake air as much as possible. This increased ventilation needs to occur during these activities and for a short time after this work is completed.

If only limited areas of the building are being remodeled, adjust the HVAC system so that it does not distribute contaminated air throughout the rest of the building. Consider using temporary exhaust systems to remove contaminants during the work. It may be necessary to modify HVAC system operation during and after these activities (e.g., running air handling units on 100 percent outdoor air for some period of time or running the system for several complete air exchanges before occupants return to the building.

Most building ventilation systems change the air in the occupied spaces six times per hour, however most of this air exchange is recirculated air (air does not leave the building). Normally one air exchange per hour of outdoor air occurs in most well ventilated buildings. To remove 95 percent of the contaminated air from a building requires five exchanges of outdoor air into a building which is about 5 hours of building operation.

If possible, schedule activities, where solvents will be released, to occur late in the day or on Friday so the building can air out over night or for the weekend. Have carpeting installed on a Friday, so the solvents in the carpet and its adhesive have the weekend to air out before the tenants return to work.

Appendix B EPA/NIOSH Building Air Quality: A Guide for Building Owners and Facility Managers